SCOPE, SEQUENCE, and COORDINATION

A National Curriculum Project for High School Science Education

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Student Materials

Learning Sequence Item:

1007

Fossils and Lithologic Units

May 1996
Adapted by: Tom Hinojosa

Contents

This micro-unit was adapted by **Tom Hinojosa** (SS&C Center Coordinator, Santa Clara, Calif.)

Science as Inquiry

A Journey Through Time

What ancient events changed life on Earth for all time?

Overview:

How long have you been alive? How did events early in your life contribute to who you are today? The Earth has been around much longer—and comprehending the vastness of time and the history of the Earth is no easy task. In this activity you will learn about events from long ago as indicated by fossils and other geologic evidence. What are some significant events that have contributed to how the Earth and life is today?

Procedure:

In this activity, you will map important bits of data about the stages of evolution and the history of the earth on a timeline. Using the paper your teacher provides, create a timeline (1-meter long). On your timeline, use the scale of 1 mm = 5 million years. Therefore, your 1-meter timeline (1,000 mm) represents 5,000 million years (5 billion years). You may wish to enlarge your timeline on a bigger sheet of paper to make it easier to map multiple events in the space available. Be sure to map all italicized events described in the data provided. Your teacher may suggest that you use colored pencils to color-code events to the appropriate segments of the timeline. As you map the data look for reasonable connections that would explain the reported findings.

Data. Geological history is divided into five eras. The first two eras: the Archean and the Proterozoic, together known as the Precambrian, account for over 90% of all Earth history. Approximately 4,500-million years ago (4500 mya), at the beginning of the Archean era, the Earth began to form by condensation of dust particles into a molten mass. As this mass began to cool, a rock crust formed on the surface. Radiometric methods using Uranium-238 (half-life 4.5 billion years) makes it possible to date the oldest rocks in the crust. The oldest rocks known on Earth formed about 3800 mya. A primitive atmosphere was formed by gases escaping from the molten rock, composed primarily of hydrogen, carbon dioxide, ammonia, and water vapor. There was no free oxygen in the air for the first third of Earth history.

As the Earth continued to cool, water vapor began to condense and formed rain which formed the oceans. Organic molecules necessary for life could now be created out of inorganic molecules by chemical reactions in the process of biochemical evolution. These reactions led to the essential building blocks needed for the emergence of earliest life, about 3500 mya.

Early life forms were simple single-celled organisms without a nucleus (prokaryotes) similar to modern-day bacteria. The early prokaryotes fed on the existing inorganic molecules and eventually began to deplete the supply. Those organisms that could synthesize their own energy source (photosynthesis) survived. About 3000 mya self-feeding (autotrophic) prokaryotes, like blue-green algae, evolved. Structures called stromatolites have been found that are made of alternating thin layers of silt and calcium carbonate made by algae. Stromatolites are not the plants’ remains. They are structures that were formed around the plants. Diatoms and bacteria can also make stromatolite structures. The early atmosphere on earth was rich in carbon dioxide for use in photosynthesis, but as a by-product of photosynthesis, free oxygen began to accumulate in the atmosphere at this time.

Early in the Proterozoic (beginning 2500 mya) the prokaryotes diversified into many types of single-celled forms. Eukaryotic organisms (having hereditary material in a cell nucleus) may have first appeared as early as 1200 mya. Soon thereafter, the plant and animal phyla diverged. Sexual reproduction probably evolved around 1000 mya. The combination of hereditary information from two different parent organisms created more diversity and enhanced the rate of plant and animal differentiation in the late Proterozoic. Multicellular plants and animals first appear in the fossil record about 750 mya. The early soft-bodied animals did not preserve well in the fossil record.

Plant and animal expansion continues through the Paleozoic era (570 mya) and into the Mesozoic era (225 mya) and the Cenozoic era 65 mya to the present.

Questions:

1. Stromatolites are reef-like structures built by ancient algae. Stromatolites still form today, but only in rare locations. Most are found in intertidal or shallow-water areas. Precambrian stromatolites are presumed to have formed in this same kind of environment. What conclusions can you make about the history of Earth based on these stromatolites?

2. “The arrival of the blue-green algae marked a point of no return in the history of life.” Explain what is meant by this statement and the significance of blue-green algae in the evolution of early life.

Science as Inquiry

A Traditional Layer Cake

What conclusions can be reached by studying sedimentary rock layers?

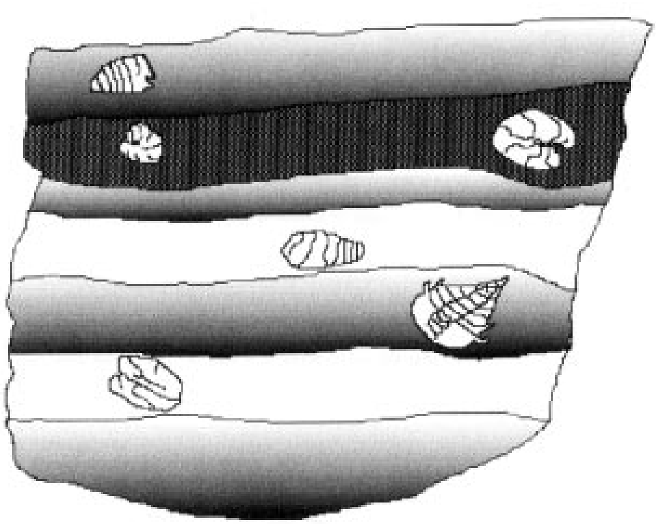
Overview:

Paleontologists, archaeologists and other scientists studying evidence from the past base conclusions about their findings on partial evidence. Here is your chance to practice scientific reasoning based upon a simple model and some simple fossils encased in a rock sample.

Procedure:

Part A. Note each of the materials provided to you by your teacher. Create a data table to include your descriptions and observed properties of each material. Partially fill the jar with the various materials in no particular order. Fill the container with water so that all the material represents a muddy stream. Shake the jar and then let it stand; note the size and kinds of materials which settle to the bottom first.

Part B. Geologists and paleontologists search for evidence to confirm existing theories. The study of rock layers and the fossils they contain relies on careful consideration of the facts and reasonable inferences and conclusions based upon the facts. Examine the "rock sample" illustrated below and determine if the statements listed beside it represent an inference or a fact. Discuss each one with a partner until you agree upon an explanation for your decision. Note: This "sample" was removed from the ground exactly as shown (the top portion of the rock was nearest the surface).



Statement	Fact	Inference
1. The rock sample has 7 layers.	❑	❑
2. The oldest layer is found at the bottom.	❑	❑
3. The youngest layer is found at the top.	❑	❑
4. This sample is a sedimentary (or layered) rock type.	❑	❑
5. Dinosaurs probably existed when these fossilized organisms were alive.	❑	❑

Questions:

Part A.

1. Describe the results of your jar sedimentation model. How does it compare with processes which occur in the natural world?

2. Explain how shells and bones might be found in sedimentary rock.

3. How is the study of fossils and rock layers related?

Part B.

4. What can you conclude about the relative ages of the fossils seen in the rock?

5. In two of the rock layers no fossils are seen. How would you explain this?

6. What do the shapes and structures seen in the fossils tell you about the ancient environment in which they lived?

7. What events could alter this rock arrangement? How might the changes confuse our study?

Science as Inquiry

Rock and Rolling Rivers

What can you interpret about geologic history from a geologic map?

Overview:

What do you think about when you hear the word canyon ? What you probably don't think about is the thousands of years it takes to form a canyon, the slow erosion by running water, and the age of the rocks exposed there. Radiometric dating helps us approximate the age of rock units. What can you learn about the geologic history of an area by studying geologic maps and data of that region?

Procedure:

Look over the materials used in this activity, including the physical map of the United States, the Geologic Map of Flaming Gorge, Utah (Fig. 1), and the Table of Rock Units found in Flaming Gorge. Use the physical map of the United States to locate the area illustrated in the geologic map. Note the mountain range where the Green River begins and the river's tributary system.

Now look carefully at the geologic map. The relief of an area is the difference between the highest and lowest points of elevation of an area. Determine the approximate relief of the map area.

Use the geologic timeline from Activity 1 to fill-in the information for Geologic Era for each rock unit described in the table.

Questions:

1. Look at the geologic map of the Flaming Gorge. What is the oldest rock unit shown on the cross section? What is the youngest? If you were standing on the Dinwoody Formation, which way would you walk on the line of the cross section to reach the older rocks?

2. Assuming that the layers of sedimentary rock have not been overturned, what is the physical relationship between the oldest rock units and the younger rock units in Flaming Gorge?

3. Locate the fault on both the map and cross section. Identify two rock units in contact with the Uinta Fault. What is the age of the fault relative to these rock units? How do you know?

4. Which rock unit forms the rim of Horseshoe Canyon? What does that indicate about the resistance to erosion of that unit compared to the rocks above it?

5. Where would you go in the Flaming Gorge area to look for fossil evidence of the oldest multicellular plants and animals? Explain your reasoning.

6. What type (if any) of fossil evidence would you expect to find in the Uinta Mountain Group? Explain your reasoning.

7. In which rock units (if any) of the Flaming Gorge region would you expect to find fossil evidence of dinosaurs? Explain your reasoning.

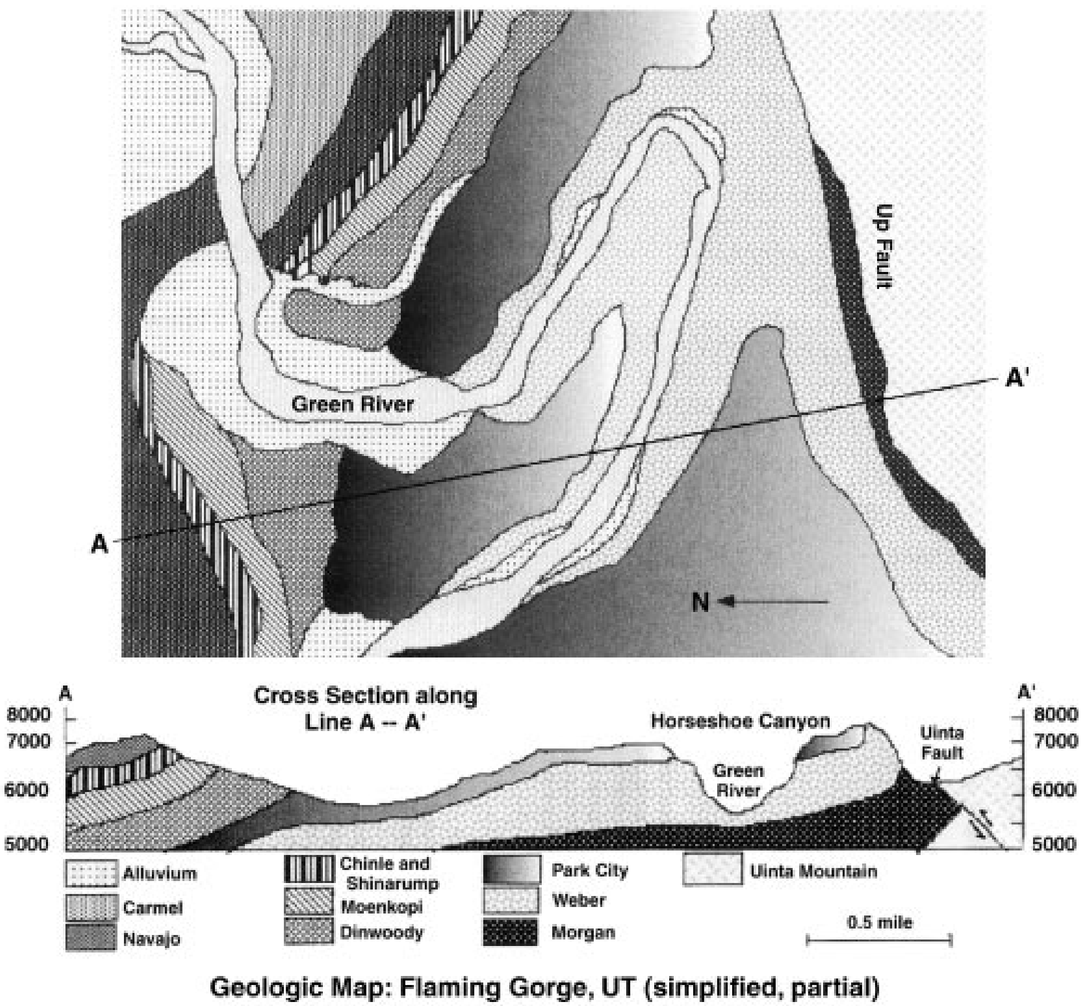


Fig. 1 Geologic map (elevation in feet).

Rock Units, Flaming Gorge, Utah

Rock Unit	Description	Estimated age (yrs)	Geologic Period	Era
Alluvium	modern surface deposits of loose sand and gravel	11,000	Quaternary	
Carmel Formation	limestone at base, with green and red shale at top	180 million	Jurassic	
Navajo Formation	cross-bedded quartzitic sandstone	150 million	Jurassic	
Chinle and Shinarump Formations	Shinarump: coarse-grained sandstone, siltstone grading up into shale; Chinle: fine-grained sandstone	210 million	Triassic	
Moenkopi Formation	siltstone with sandstone and shale	230 million	Triassic	
Dinwoody Formation	shale, siltstone and sandstone	245 million	Triassic	
Park City Formation	limestone with sandstone, shale, mudstone, and dolostone	265 million	Permian	
Weber Sandstone	mostly calcareous sand-stone	300 million	Pennsylvanian	
Morgan Formation	limestone at base, red shale and siltstone in middle, fine-grained calcareous sandstone at top	315 million	Pennsylvanian	
Uinta Mountain Group	medium- to coarse-grained, dark red, quartzitic sand-stone and quartzite	1500 million	Precambrian	

Student Sheet

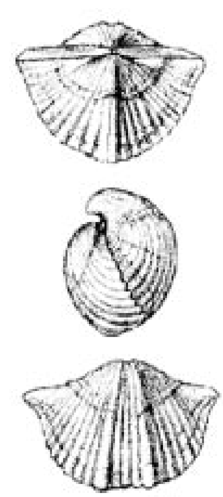
Science as Inquiry

Ruffles Aren't Ridges

How can statistical analysis help you study fossils?

Overview:

When you study fossils, you should not only try to determine what the living organism looked like, but also to determine where, when, and how the organism lived. One way to find out about how an organism lived is to study records of a population. In this activity, you will analyze data from two groups of brachiopod fossils. Brachiopods were a common shelled animal that lived on the ocean floor during the Paleozoic era. What were they like and what was the ecology of that time period like?



Procedure:

Your task is to use the available data to determine whether the two brachiopods' populations differ in any significant way. Look at the picture of the brachiopod Spirifera provided and/or a model or actual specimen if they are available. Notice how the Spirifera shell is divided in two by a central ridge. You will be provided with data taken from 100 Spirifera fossils collected from two different areas. The data tells you the number of ridges on one side of the Spirifers' central ridge.

Look over the two sets of data for the two populations of brachiopods. You must find a way to analyze the data to give you useful information on which to base your comparisons and conclusions about the two populations. A review of the following terms and applicable definitions may be helpful:

Frequency is the number of brachiopods all with the same number of ridges.

Median is the middle value of all the numbers in the data set if they are listed in numerical order; (half the brachiopods will have more ridges than the median; half will have fewer ridges).

Mode is the number of ridges that occurs most often in the data set for each population.

Data

Population 1					Population 2				
12	10	11	9	11	21	19	18	14	18
12	11	13	11	14	18	17	19	22	18
10	12	11	14	10	20	16	17	19	18
11	11	9	10	15	17	18	18	15	19
10	11	11	12	11	19	17	18	16	19
12	12	10	10	11	18	17	16	20	20
11	10	9	11	13	20	18	20	19	17
11	11	11	12	8	16	15	21	16	19
10	11	10	11	11	17	18	19	19	17
12	11	12	10	12	17	18	16	17	20

Mean is the “average” of all the values in each data set (find the sum and divide by the number of values used to determine the sum).

Discuss with your lab partner(s) what would be the most useful strategy for purposes of comparisons between the two brachiopod populations. You may want to consult with your teacher before you finalize your analysis strategy. Create a data table to record your calculations. Be sure to label each data table if you create more than one.

Create a corresponding graph to go with each data table you create. Use colored pencils to plot data for both populations on the same graph(s).

Questions:

1. Based upon the data and your analysis, do you conclude that there are distinct differences between the two populations? Justify your answer with specific evidence from the data, your calculations, and/or your graphs.

2. Counting the number of ridges on the brachiopod shells is just one way to analyze the brachiopod population. What are some other ways?

3. You are given three brachiopod fossils which were mistakenly left out of the original data set you just worked with. You do not know where these samples were collected. Two of the shells have 9 ridges, and one shell has 11 ridges. Based on your data and analysis, can you determine to which population they belong? Explain your answer.

4. You return to the site where Population 2 fossils were collected. You find 50 more brachiopod fossils in a layer of younger rocks. You count the number of ridges on each shell and determine that the mode is 23 ridges and the median is 21. How would this new data change your overall analysis of Population 2?

5. Based on the new Population 2 fossils described above, what can you conclude about the evolution of brachiopods at that location? What might this indicate about the environmental conditions and other life forms of that time period. Is there an evolutionary advantage based upon the shell structure(s) of brachiopods?